Fig: 1

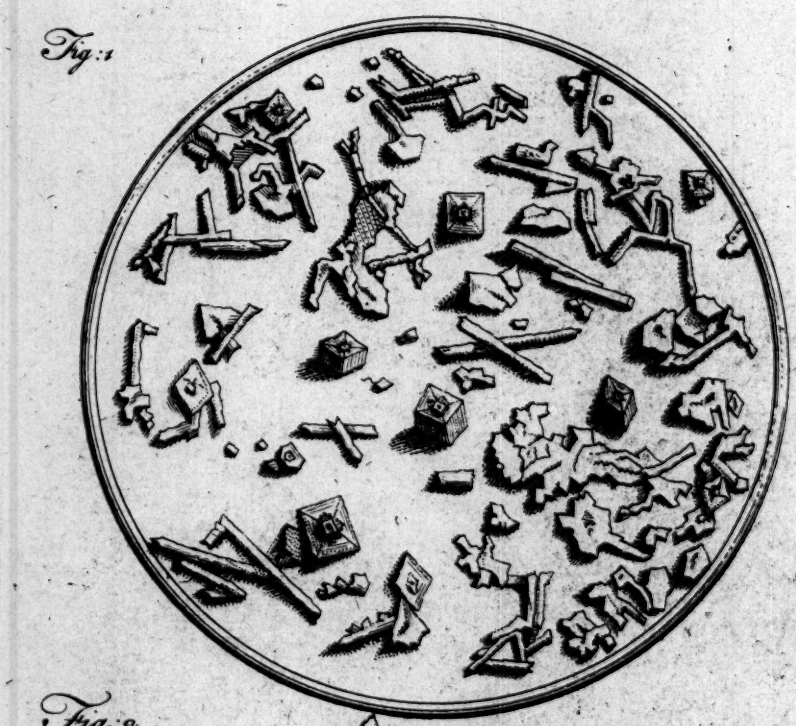

Fig: 2

Fig: 1

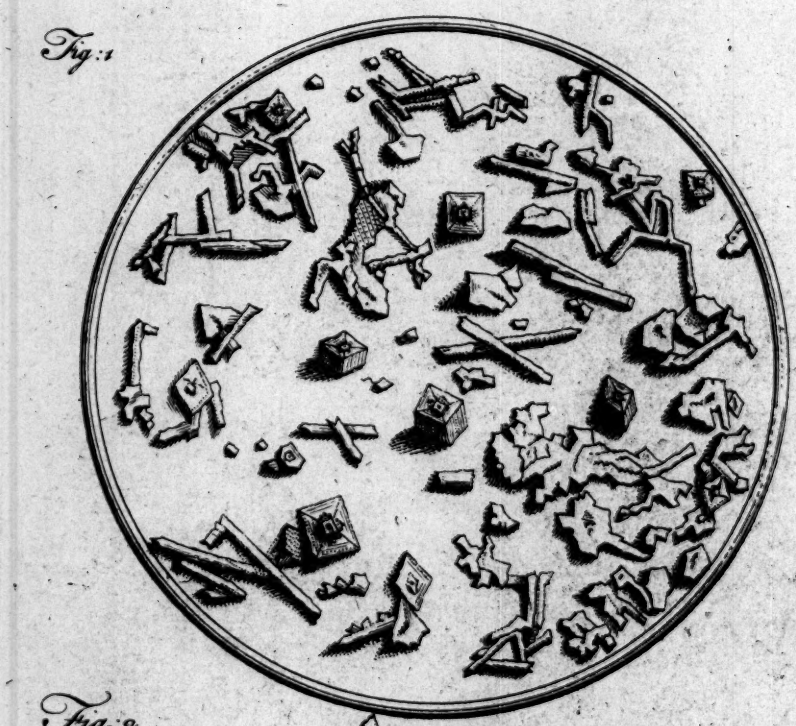

Fig: 2

3

A

CHYMICAL ANALYSIS

OF THE

BATH WATERS,

Containing an Account of the

MINERAL SUBSTANCES

Which the BATH WATERS bring up with them out of the Earth;

The CHALYBEATE, SULPHUREOUS, SALINE, and EARTHY PRINCIPLES of them;

AND

How the Bath Waters are generated.

BY

R. CHARLETON, M. D.

PHYSICIAN to the GENERAL HOSPITAL.

SECOND EDITION.

——— Inter ſe quia nexus principiorum,
Diſſimiles conſtant.———
Incolumi remanent res corpore, dum ſatis acris,
Vis obeat pro textura cujuſque reperta. LUCRETIUS.

BATH: Printed by R. CRUTTWELL,
For W. TAYLOR, in Church-Street, Kingſton-Buildings;
AND SOLD BY
R. BALDWIN, No. 47, in Pater-noſter-Row, London.
[*Price One Shilling and Six-pence.*]

M DCC LXXVI.

TO HIS GRACE

THOMAS,

DUKE of LEEDS,

MARQUIS of CARMARTHEN,

KNIGHT of the moſt noble ORDER of the GARTER,

L. L. D. and F. R. S.

A GOVERNOR of the GENERAL HOSPITAL at BATH.

MY LORD,

AS the following ſheets conſiſt chiefly of teſtimonies, which prove the great utility of our General Hoſpital, I know not to whom they can with more propriety be addreſſed than to ſo warm and generous a patron, as your Grace is known to be, of this excellent inſtitution.

At the ſame time, my Lord, I ſhould ill deſerve the many favours I have received from you, and that honour I derive from your friend-

 ſhip,

ſhip, was I not to confeſs there is another motive for my prefixing your Grace's name to this publication.

This other motive, my Lord, is gratitude; which, joined to the moſt perfect eſteem and reſpect, muſt ever make me,

YOUR GRACE'S

Moſt obedient

and moſt obliged

humble Servant,

R. CHARLETON.

TRACT

3

TRACT

THE FIRST,

CONTAINING

A

CHEMICAL ANALYSIS

OF

BATH WATERS.

BY

R. CHARLETON, M. D.

SECOND EDITION.

——— Inter ſe quia nexus principiorum,
Diſſimiles conſtant. ———
Incolumi remanent res corpore, dum ſatis acris,
Vis obeat pro textura cujuſque reperta.

LUCRETIUS.

ADVERTISEMENT.

THE following Tract has long been out of print. The author's deſire of rendering it more perfect is the reaſon why it was not ſooner republiſhed. He had, indeed, made his experiments with care, and had reported them with fidelity; but as he found other gentlemen engaged in the ſame purſuit, and as he was but too well acquainted with the difficulties of the inquiry, he waited for their publications, in hopes to have been enabled by ſuch helps (with all due acknowledgment) to have corrected the imperfections of his own.

In ſome of theſe treatiſes, on the compoſition of Bath waters, which have appeared ſince his was publiſhed, he has ſeen his opinions controverted. In others, he has ſeen thoſe objections, which were raiſed to his opinions, removed.

He finds himſelf therefore, upon the whole, under no neceſſity of departing from his original ſentiments, nor has he been able to collect, from ſubſequent writers, any thing which he thinks is very material to add to them. He muſt here except one diſcovery which has been made by Dr. Falconer, who has found that fixible or mephitic air enters the compoſition of theſe waters in conſiderable quantity. A principle with which chemiſtry had little or no acquaintance at the time this treatiſe was firſt publiſhed.

But the grounds on which he builds this adherence to his former ſentiments will the more evidently appear by collecting under one view the ſeveral ideas which the principal analyſers of theſe waters entertain of their contents. From hence it will be ſeen in what particulars they all agree; in what they really differ; and where their difference is more nominal than real.

In the opinion of the author of this analyſis, the ingredients which impregnate theſe ſprings are iron, earth, common ſea ſalt, a neutral ſalt, elementary fire, and a ſulphureous matter.

In

In the opinion of Dr. Lucas, their principals are iron, an abſorbent earth, common ſea ſalt, a priſmatic bitter ſalt, a portion of oil, and a vitriolic acid *per ſe*.

In Dr. Falconer's opinion, they are compoſed of iron, ſelenites, common ſea ſalt, common air, mephitic air, and hepar ſulphuris cum calce viva.

From this view it may be obſerved, that all theſe analyſers agree in allowing the Bath Waters to contain iron, common ſea ſalt, earth, and a ſulphureous matter. And it will not be here improper to remark, that none of them mention common ſulphur or brimſtone, as exiſting under that *ſpecific form* in their compoſition.

But though all theſe writers allow there is an ingredient of a ſulphureous nature to be found in theſe waters, yet they differ with reſpect to its name. One calls it a balſam, or (borrowing the expreſſion of Homberg) Le vrai ſouffre du ſouffre commun. One terms it an oil. One, a hepar ſulphuris cum calce viva.

They likewiſe agree, that theſe waters contain an earthy matter, but here too they differ as to its name. One has termed it an alcaline earth; the other an abſorbent earth; and the third a ſelenites.

There is alſo another ſeeming difference which is here to be taken notice of; I mean the neutral ſalt, which two of theſe writers mention, and which the third has omitted. But this ſeeming difficulty will vaniſh if the reader attends to what is ſaid of this ſalt in page 53 and 54 of the following treatiſe; where the author has remarked, that "he does not believe this ſalt primarily exiſts in theſe waters, (though its conſtituent parts do) but that it is generated while the waters evaporate.

So far our analyſers are found to be better friends, than the public, perhaps, has been taught to believe.

But we now come to a real difference between them.

The point in diſpute is this, namely, Whether there exiſts in Bath waters a vitriolic acid *per ſe*, or not?

Such

Such an acid in a ſeparate unmixed ſtate, or *per ſe*, the writer of theſe ſheets has declared he could not find. Dr. Lucas is poſitive in the contrary opinion, and pronounces its exiſtence to be evident. Dr. Falconer ſays its exiſtence is very dubious; and adds, "if it does exiſt, it is likely that a quantity of it, not exceeding a *drop*, is preſent in *many pounds* of the water, and as ſuch can have little power in influencing its effects."

The ſupporter of this opinion urges in its defence, that Bath Waters decompoſe ſoap and curdle milk. But theſe experiments are not deciſive, as other ſubſtances, which are not acids *per ſe*, will produce the ſame effects. It has alſo been further urged, that Bath Waters ferment with alcalies; but this is a fact which no one, who has tried the experiment with the ſlighteſt degree of preciſion, and who has not an hypotheſis to ſupport, can poſſibly allow; the aſſertion being without doubt a miſtake.

Since theſe arguments for a vitriolic acid *per ſe* in Bath waters do by no means confirm its exiſtence, there remains no other trial by which its preſence can be aſcertained, unleſs we apply to the criterion of our ſenſes: And ſince the advocate

advocate for the exiſtence of this principal lays ſo much ſtreſs upon this proof, what he has ſtill further to plead in ſupport of his hypotheſis, ought to be attended to. Let us hear then what he ſays.

In page 277 Dr. Lucas tells us, "the firſt thing remarkable that preſents itſelf to obſervation is a ſubtle acid, which flies off in vapour, and *ſometimes ſenſibly ſtrikes the noſe.*"

Now was this a fact, it would terminate the diſpute. But how can this be a fact? Seeing it is ſo diametrically oppoſite to what he tells us a little before, page 265, viz. that "the water newly drawn or taken up as near the ſource as may be, *has no ſenſible ſmell, no more has its vapour.*" Or with what he tells us a little after, page 298, that "it is true this acid is in a great meaſure ſo ſaturated with terrene matter, as well as diluted with water, *as to be imperceptible to the ſenſes.*

'Tis, indeed, unlucky to meet with ſo much contradiction within the narrow limits of ſo few pages; but it may not be without its uſe: For ſeeing one writer has declared it to be his opinion, that this acid *per ſe* does not exiſt; another

ther is in doubt if it exiſts or not; and the third not only flatly contradicts himſelf, but has unwittingly fallen into the very opinion he would oppoſe; the reader perhaps may be inclined to ſatisfy himſelf with the information which theſe ſheets afford, or determine, as a more eaſy way *tantas componere lites*, to think no more about them; which reſolution would be ſo far from diſpleaſing to the author of this tract, that he promiſes to follow the example.

A CHE-

A

CHEMICAL ANALYSIS, &c.

CHAPTER I.

Of the MINERAL SUBSTANCES *which the* BATH WATERS *bring up with them out of the Earth.*

THE origin and courſe of the BATH Waters being unknown, we are deprived of thoſe helps in our ſearch after their conſtituent principles, which an examination of the ſubſtances they run through would afford. For as all ſuch waters derive their virtues from the bodies they diſſolve during their continuance in the bowels of the earth, or from the ſteams of fermenting minerals with which they are there impregnated; an inveſtigation of this kind is too eſſential and too uſeful a part of their *Analyſis*

lyſis not to be regretted, when we are deprived of its aſſiſtance. But this defect in the preſent enquiry is however, in ſome meaſure, ſupplied by the following ſubſtances, which the current of theſe ſprings forces up from beneath.

The firſt, is a very peculiar ſort of ſand, of a dark grey colour. It appears to the eye to conſiſt chiefly of ſmall chryſtals, like thoſe of common ſand, intermixed with black ſhining particles, and pieces of a white chalky earth. But when ſubmitted to a chemical examination, we find in it an alcaline principle, iron and brimſtone.

The firſt is evident from the violent fermentation which acids produce with it.

The ſecond, from digeſting it for a few days in pure diſtill'd rain water, which will thence become poſſeſſed of all the properties of a natural chalybeate: Or, if a loadſtone is moved about in this ſand, ſeveral ſmall particles of iron will be attracted from thence by it.

The third ingredient which enters its compoſition, viz. brimſtone, is diſcoverable from ſtrewing a ſmall quantity of this ſand on a red-

hot

hot poker, where it yields a blue flame, and a ſuffocating vapour: Or, from confining ſome of it in a retort, whence the true acid ſpirit of that mineral may be obtained by diſtillation.

To this ſand ſucceeds a ſoft black mud, of a ſtrong ſulphurous ſmell; which yields, by the before-mentioned proceſs, a conſiderable quantity of a taſteleſs, limpid, fœtid water, that fermented with neither acids nor alcalies. The neck of the retort was lined with a fine ſtraw-coloured powder, which glittered, was taſteleſs, and gave no blue flame in burning; but the vapour which aroſe from it was acid and ſuffocating. This mud being rubbed on ſilver changes it black.*

In ſome of the ſpring and ſummer months, it is uſual to ſee large black cakes floating on the ſurface of theſe waters. They have been ſuppoſed to be ſome bituminous matter, but are in reality, a moſs,† as is evident by keeping a

 part

* Both the ſand and mud are found in the ciſterns, which are placed over the ſprings of the ſeveral baths.

† Mr. Ray in his *Synopſis Stirp. Britannic.* calls this plant the *Jelly-Moſs.*—Conſerva Gelatinoſa, omnium tenerrima & minima aquarum limo innaſcens.

part of them for a few hours in a glaſs of common water, which by waſhing off the mud in which it grows, and that clots its fibres together, gives them liberty to expand, and to demonſtrate their being a vegetable from their *figure*. By diſtillation it produces the uſual component principles of its tribe; from whence, with its being commonly to be found in other places,* it cannot be ſuppoſed to impart any peculiar virtues to the Bath Waters: But how far they are obliged to either of the two preceding ſubſtances in this reſpect, we ſhall have a more fit opportunity hereafter of ſhewing, when it is diſcovered of what ingredients they are compoſed.

* Gaudet limo nigro tenero & pingui & in foſſis purioribus paſſim circa Londinum obſervetur toto fere anno.

Synop. Stirp. Britan.

CHAP.

CHAP. II.

Of the CHALYBEAT PRINCIPLE *in the* BATH WATERS.

THE BATH WATERS have ever been deemed chalybeat; and it is evident they are ſo, as well from their ſmell and taſte, as from the phænomena produced in them by their mixture with the following materials.

1ſt. The water of each bath, *viz.* the King's, Hot, and Croſs, inſtantly changed with powder of galls to a rich purple.

2d. With a few grains of powdered log-wood, they at firſt ſtruck a reddiſh purple, and in leſs than a quarter of an hour turned of a deep violet.

3d. With green tea they acquired the ſame colour as with galls, but much fainter.

4th. With pomegranate bark they became of a bluiſh caſt, when placed in ſome lights, and of a greeniſh yellow in others, like thoſe changeable ſilks, whoſe colours vary

according to the different points of view are they obſerved in.

5th. Balauſtines* produced in theſe waters a colour, which at firſt reſembled that of galls, but it afterwards altered to a greeniſh hue.

Theſe changes which galls and other ſimilar ſubſtances excite in mineral waters, are held to be a ſure criterion of their containing a chalybeat principle; and experiments of this ſort are commonly confined to a bare demonſtration of its exiſtence. But as it has been found by frequent trials, that ſuch waters *vary* from the fainteſt ſhade of purple to the deepeſt black, in proportion to the quantity of this ingredient, which they are poſſeſſed of; and as they require a larger or a ſmaller quantity of galls to bring them to their higheſt tint, in the ſame ratio; ſuch experiments may be conducted to a more uſeful purpoſe, than that to which they are commonly aſſigned: For it becomes a matter of no great difficulty, by preparing an *artificial chalybeat* water, in which a known portion of this metal is diſſolved, to determine how much

* Flowers of the wild pomegranate tree.

much of it exists in the *natural one*: It being a necessary consequence of the above observations, that where two waters strike the same colour with equal quantities of galls, that each must contain the same quantity of iron.

Mr. *Monro*, of *Edinburgh*, to whom the physical world is much obliged for many useful and curious discoveries, has, in the third volume of the *Medical Essays*, given us one on the present subject; in which he says, that in the salt of steel the proportion of iron is little more than a third part, and that by dissolving one ounce of it in twenty ounces of water, 142 drops of which solution weigh two drams, every such drop will contain $\frac{1}{75}$ of a grain of iron.

I prepared such a solution of the salt of steel, by dissolving 240 grains of it in 10 ounces *averdupois** of water, and found, by a very accurate ballance, that 97 drops of it, let fall from a small glass tube, exactly weighed two drams. These drops were therefore larger than those in Mr. *Monro*'s calculation, and each of them contains $\frac{1}{77}$ of a grain of iron.

* This is mentioned, because in Mr. *Monro*'s solution, the water was weighed by troy ounces.

At the ſame time a ſtrong tincture of galls was alſo made, by digeſting one ounce of them in powder, with a pint of rain water, in a gentle heat for ſome days; and with theſe helps I proceeded in the following manner, to diſcover the quantity of the chalybeat principle, with which the Bath Waters are impregnated.

I dropped the tincture of galls from a ſmall glaſs tube, in different quantities, into pint glaſſes, of the ſame ſhape and thickneſs; and then immediately filled them with the water as it came hot from the pump. It was found, by repeated trials, that ten drops of this tincture were the preciſe number, which brought the water of the King's Bath to its higheſt tint; and that five drops were ſufficient for this purpoſe in thoſe of the Hot and Croſs Baths.

The water of the King's Bath ſtruck a warm, rich, roſy purple; the others only differed from it in their ſhades being lighter.

To imitate the colour of the King's Bath Water, two drops of the ſolution of iron abovementioned, added to three pints of pure rain water, were ſufficient: For thus an artificial chalybeat was produced, one pint of which

ſtruck,

ſtruck, with ten drops of the tincture of galls, a purple, from which that of the natural one was not to be diſtinguiſhed, but by the warmth and richneſs of its tint.

It appears therefore from the preceding experiments, that the chalybeat principle in a pint of the King's Bath water, is equal to the quantity of iron contained in two thirds of a drop of the ſolution; which, by calculation, comes out to be $\frac{1}{70}$ of a grain nearly; and as the waters of the Hot and Croſs Baths are but of half its ſtrength, there is in a pint of either of theſe only $\frac{1}{140}$ part of a grain.

This diſcovery at firſt ſight may ſeem prejudicial to their reputation; but it would be doing the higheſt injuſtice to theſe waters, ſhould we attempt to explain their virtues from only a part of their compoſition; or attribute to one ingredient, what reſults from the happy combination of *ſeveral*. Beſides, this ſeeming prejudice will be entirely removed, if it be conſidered, that the ſame method of inveſtigation being applied to other chalybeat waters, ſhews they are all impregnated with this principle, in a degree infinitely inferior to what might be imagined.

Should

Should we not alter our opinion of the powers of ſteel medicines from hence? And conclude, as nature deals this mineral out ſo ſparingly, in her moſt ſanative compoſitions, that its efficacy depends far leſs on quantity than the common uſage of preſcribing it ſuppoſes.

It has been ſaid, that the chalybeat principle of the Bath waters is *volatile*; that they loſe it by keeping; and through its eſcape, become vapid and effœte. The falſity of which poſition will be ſhewn by the following experiments.

1. Having filled a large bottle at the pump of the King's Bath, a wet bladder emptied of its air and with its ſurface well oiled, was tied cloſely over its mouth; after a time, the bladder became diſtended, and the vapour which was thus collected, being gathered into a large bubble, was ſunk to the bottom of a glaſs which contained a weak tincture of galls. Upon running a pin into that part of the bladder, where this vapour was, it ruſhed out with conſiderable noiſe, produced great agitation in the liquor, and filled it with blebs of air, which burſt as they arrived at its ſurface,

face, but excited no alteration in its colour, or ſhewed the leaſt marks of a *volatile* chalybeat.

2. A large quantity of the King's Bath water was diſtilled from a retort, in whoſe neck a hole was made, through which its more volatile parts might eſcape; over this hole was placed a piece of ſpungy paper, that had been ſoaked in a ſtrong tincture of galls. The paper was rolled up into a conical ſhape, and covered with a glaſs bell, which condenſed thoſe vapours which aroſe in the diſtillation, and returned them again upon it. The conſequence of this experiment was, that though the paper became thoroughly wet with the vapour, yet it was changed to neither a purple or a black colour.

3. I put into a receiver a few fragments of a gall nut, and diſtilled the water of the ſame bath into it from a glaſs retort, having firſt of all well ſecured their junction by cement and wet bladders. The water which was thus diſtilled remained entirely free from any the leaſt tint, which could raiſe a ſuſ-

a ſuſpicion of its being impregnated with iron.

The received notion therefore, that the Bath waters contain a *volatile* chalybeat principle, is without foundation. Surely its effects muſt have appeared in one or other of theſe trials, either of which was ſo ſuſceptible of demonſtrating its exiſtence: For one drop of a weak ſolution of iron tinctured the fluids of the firſt and third experiments with a very diſtinguiſhable purple, and being poured on the paper which was uſed in the ſecond (after it was dry) gave it a blackneſs equal to what it would have acquired, had it been dipped in ink.

But it may be aſked, if the chalybeat principle of the Bath waters is not *volatile*, and does not fly off from them; why do they loſe their power of tinging with galls by being kept? The following experiments will tell us:

Two Florence flaſks were filled with this water, and their noſes inverted into decanters of the ſame. One of the flaſks was quite full; the other had an air bubble left on its ſurface of two and ½ inches diameter. After 24 hours each was examined

mined with galls. The water in the flaſk where the air bubble was left, ſhewed ſcarcely any tinging property; but that in the other, which was quite filled, ſtruck immediately a vivid purple, nearly equal to what it gives when juſt taken from the pump.

Hence we ſee the water is deprived of this power by a bare communication with the air; and that even when it is preſerved in ſuch a ſituation as renders the eſcape of its chalybeat principle impoſſible. It would be abſurd to ſuppoſe *this* could paſs through the pores of the glaſs; or granting it to be capable of obtaining ſuch a paſſage, 'twill be a matter of the utmoſt difficulty to explain, why it did not leave the waters in each flaſk alike?

It is to the air therefore alone, that ſuch alterations are to be attributed, which (to uſe the words of a very judicious writer*) "by its in-"ceſſant elaſtic action, promotes ſome degree "of agitation or ferment in the water, cauſing "the mineral particles thereby to diſentangle "themſelves from the water, and to coaleſce into

* See Dr. *Hale*'s Experiments on Steel Waters, &c. Page 105.

" into new combinations of ſo much larger ſize
" as diſqualifies them to be any longer ſuſpended
" in the water; they then precipitating to the
" bottom and ſides of the bottles, partly in the
" form of a yellowiſh ocre, and partly in cloudy
" flocks or thrumbs."

Where the air is ſecluded, no change of this kind enſues; nor does it happen to a water with which ſome acid ſpirits have been mixed; theſe being repugnant to any putrid agitation which that reſtleſs element can excite.* Beſides it is a fact, that when the Bath waters have loſt their tinging properties, they will acquire them again after they have undergone a thorough fermentation; which it would be impoſſible they could do, was their chalybeat principle *volatile*.

What

* Acid ſpirits, beſides their power of preventing any putrid agitation in the water, have ſtill a further one which greatly contributes to preſerve its tinging properties, and that is, their keeping the chalybeat principle ſufficiently diſſolved, attenuated, and mixed with the water: And hence, by dropping ſpirit of ſulphur, or ſpirit of vitriol, into the Bath waters, I have preſerved their tinging properties for a great length of time, though the bottles in which they were kept have been corked only in a common manner. Without theſe acid ſpirits, the waters are entirely deprived of them in a few days.

What theſe waters principally loſe when they are withdrawn from their ſpring, is their elementary fire.

I had a glaſs veſſel made of a globular ſhape, from whence aroſe two tubes, the one capillary, the other of $\frac{1}{4}$ of an inch diameter, and both of three inches in length. This veſſel was filled with the water of the King's Bath, taken hot from the pump, to the top of each tube; the larger of which was then covered with a piece of gold-beater's ſkin, and ſome putty, which ſeparated its contents from all contact with the external air. By the next morning the water in the capillary tube had ſunk 2 and $\frac{1}{2}$ inches nearly, and required ſix grains of the ſame water (which was cold) to raiſe it to the height it was firſt at.

Hence we ſee the Bath water increaſes in its ſpecific gravity, as this principle flies off from it; and that its particles approach nearer to each other, and the whole volume of the fluid is condenſed. Which alterations in the arrangement and mixture of its component parts, joined to the loſs of this ætherial fire, is probably

bably the reaſon why its virtues can never be reſtored, when it is once grown cold.

The heat of the ſeveral baths, as taken by *Farenheit*'s mercurial thermometer, is as follows:

The water of the King's Bath, where it is of the greateſt warmth, raiſes the mercury to 103 degrees; and ſinks it from thence, in its cooleſt part, to 100.

The thermometer ſtands in the Hot Bath at 100, or 101.

The different degrees of heat in the Croſs-Bath, are 93 and 94.

The heat of the Queen's-Bath, is from 99 to 98.

The waters which are pumped up from the *ciſterns* of the ſeveral baths for *drinking*, and which are conveyed through pipes immediately from their ſource, were found to be of various degrees of heat, at different times of trial.

Thus the water which flows from the pump of the Croſs-Bath, has deſcended from 110 degrees, through all the intermediate ones, to 105.

That

That of the Hot-Bath,* from 116 to 112. And the water of the King's-Bath pump, from 116 to 114.

It is uſually thought, that the Bath water retains its heat longer than common water heated to the ſame degree; but it did not appear to do ſo, by the moſt accurate experiments that could be made.

It were to be wiſhed, among the ſeveral conveniences of bathing and pumping which the different heats of theſe baths afford, that we had a *vapour* bath; or a contrivance to let out the ſteam of the water (to which an artificial heat might be given where the natural one was inſufficient) on any part of the body whence obſtructions were to be removed. The advantages of ſuch an application are much ſuperior in many caſes to the common methods of pumping, and are attended with none of its inconveniencies.

The amazing power of warm vapour has been abundantly ſhewn by its effects in *Papin's Digeſter*, where the hardeſt bones are in a few moments

* Since the ſpring of the Hot Bath has been ſecured, the heat of this water is much increaſed.

ments rendered ſoft and pappy; but a ſimple experiment is ſufficient for our purpoſe, to demonſtrate how much more penetrating and diſſolvent water is when thus rarefied, than in a more condenſed ſtate, though poſſeſſed of the greateſt heat it is capable of attaining.

Put a ſmall quantity of ſalt of tartar into a glaſs pan, and tie a piece of dry bladder over its mouth: Now boiling water may be for a long time poured on this bladder, without getting through its pores; whereas the ſteams of ſuch water gain an immediate admiſſion, which they demonſtrate by diſſolving the ſalt almoſt as ſoon as they are applied.

The inconveniences of *pumping* proceed from the weight and preſſure of the water, which (together with its heat) excite a vibratory and impulſive motion in the obſtructed veſſels, that puſhes forward their ſtagnant contents. If theſe are liquid enough to paſs the bounds of their confinement, ſucceſs will attend the application. But where they are too viſcid; where they are endued with an acrimonious diſpotion; where the conſtitution of the patient is hot

hot and feveriſh; or at leaſt in that ſtate at the time of uſing the *pump*, an inflammation of the part muſt be the conſequence; which, if great care be not taken, is followed by a generation of *matter*, whoſe moſt favourable termination calls for the *cauſtic* or *inciſion-knife*.

But none of theſe *ills* can proceed from the *vapour* bath: It removes obſtructions by diſſolving the hardened juices which form them, and not by ſtimulating the veſſels to puſh them forward through narrower *paſſes* into the wider *roads* of *circulation*. The particles of water in this attenuated ſtate, find an entrance through the pores which is denied them in any other; and by the relaxing quality which theſe vapours poſſeſs, they open an eaſy paſſage through the ſkin for the obſtructed *humours*, while they liquify them ſufficiently to make their eſcape.

CHAP. III.

Of the SULPHUREOUS PRINCIPLE *in the* BATH WATERS.

IT is a controverted point, whether or no the Bath Waters are impregnated with ſulphur. Probably the indiſcriminate uſe of that term, and of common *brimſtone*, has been the occaſion of this diſpute. The latter is only applicable to a particular mineral, whoſe characteriſtics are, its yelloviſh colour; its great inflammability; its burning with a blue flame, and an acid ſuffocating vapour: Whereas the former ſhould be underſtood in a much more extenſive ſenſe, ſo as to comprehend all *unctuous bodies* in general. And hence, if any ſuch can be diſcovered in theſe ſprings, it has all juſt right to be called their ſulphureous principle, how much ſoever it may differ from common brimſtone.

It has already been ſhewn that this mineral exiſts in the Bath ſand; but whether it actually enters the compoſition of the waters, is what I ſhall here endeavour to decide.

I judged

I judged that the moſt likely means of ſucceſs would be to make artificial brimſtone waters, and to add a diverſity of mixtures to them and to the Bath waters at the ſame time: It would be thus eaſy to diſcover how far the phænomena produced in each agreed; and conſequently whether the natural water was impregnated with the ſame ingredient as the artificial one, or not.

With this view, therefore, there were prepared two ſorts of brimſtone waters. The *firſt*, by melting the flower of brimſtone with ſalt of tartar, which together conſtitute a mixed body that readily diſſolves in water. The *ſecond*, by pouring common ſpring water on pounded ſtone brimſtone, and returning it on again after it had ſoaked through, till it became ſufficiently ſaturated with that mineral.

To equal quantities of theſe fluids, there were added 30 drops of a ſolution of *ſublimate* in diſtilled rain water; and at the ſame time a like number were dropped into that of the bath.

Number I. or the water prepared with brimſtone and ſalt of tartar, changed inſtantly to a fine orange colour: Afterwards, it

grew thick, and let fall a yellowiſh ſediment; which being dried, was flung on a red-hot iron, where it burnt with a blue flame.

Number II. or the artificial water made from brimſtone alone, appeared of a beautiful pearl when held from the light; but oppoſite to it of a ſtraw colour. On ſtanding it became opake and milky, and a fine white powder precipitated which burnt blue on a hot iron.

The Bath water ſhewed no alteration at firſt from this mixture; but at length a ſcum aroſe, and covered its ſurface, which reflected an infinite variety of the moſt beautiful colours.

From this claſs of experiments, we find that the Bath water bears no kind of ſimilitude to the artificial ones: We ſhall therefore examine them with a ſolution of *quickſilver* in *aqua fortis*, added to each in the ſame quantity as before: With this,

Number I. became firſt of an orange, and afterwards turned to a pearl colour. Its preci-

precipitation, which was of a cream, yielded a weak blue flame in burning.

Number II. became milky. In a ſide light the mixture had a bluiſh tint; in an oppoſite one, a faint yellow. The powder which was depoſited at the bottom of the glaſs, was white, and burnt blue.

The Bath waters reflected a fine bright orange. Its ſediment was of the ſame caſt, and ſhewed no ſigns of inflammability.

We here find ſome reſemblance between the Bath water and No. I. which conſiſts in their both ſtriking pretty nearly the ſame colour: But as this is owing to the *alcaline* principle that each contains, as will be ſhewn when we come to treat of the ſalts and earths which are in the Bath waters; it muſt not from this ſimilarity alone be concluded, that they are both impregnated with the ſame ſulphureous ingredient.

A third trial was made on each of theſe waters with a ſolution of *ſilver* in *aqua fortis*.

In Number I. the liquor at top was of a dirty white, at bottom of a dark brown.

The precipitation was of a greyiſh colour, and burnt with a pale blue.

In Number II. the fluid was dark and muddy. A black ſhining powder ſubſided, which flamed with a vivid blue.

In the Bath water, dark clouds were inſtantly formed, which gradually becoming black, at length deſcended and formed a ſediment of the ſame colour. This black matter gave no flame on a red-hot iron, but ſmoaked much, and turned to a calx.

All theſe waters agree here in one particular, which is the blackneſs they give to the ſilver that's precipitated. This we know is one of the properties of common brimſtone; it is owing to the acid part of that ſubſtance; and other mineral acids are capable of producing the ſame. Thus if pure diſtilled rain water is well ſaturated with common ſalt that has been purified for uſe, it changes the ſilver which it precipitates equally black with the above-mentioned waters. It does not therefore follow from this experiment alone, without the aſſiſtance of other concurrent proofs, that the Bath water

water is impregnated with *common brimſtone*. But upon the whole the contrary is to be concluded, ſeeing its precipitations have no where in theſe trials produced the genuine and diſtinguiſhing characteriſtics of that mineral, viz. a *blue flame* and a *ſuffocating acid vapour*. To which we may add, that no alterations are produced in the Bath waters with *foſſil* acids; whoſe well-known property it is to precipitate this body from the menſtruum in which it is diſſolved, and at the ſame time to occaſion a moſt fœtid diſagreeable ſmell. Neither does their reſiduum, (the ſolid contents of the water obtained by evaporation) when flung on a red-hot iron, or on live coals, give any cauſe to ſuſpect the contrary; which it moſt certainly would do, was ever ſo ſmall a portion of real brimſtone mixed with it.

As this mineral, therefore, does not enter into the compoſition of the Bath waters, I ſhall proceed to another ſpecies of enquiry by which the nature and exiſtence of their *true* ſulphureous principle will be diſcovered and aſcertained.

One dram of ſalt of tartar, and four drams of the reſiduum of theſe waters, were ground

together into a powder, and kept in a crucible over a ſtrong fire, till they grew quite hot. This powder was immediately flung into a Florence flaſk, which contained about half a pint of pure rectified ſpirit of wine. The ſpirit quickly became tinged, of a rich golden colour, and acquired, by digeſtion in a ſand heat, a grateful fragrancy of ſmell, with a hot, pungent, ſpicy taſte.

This experiment was made in imitation of the 154th proceſs in *Boerhaave*'s chemiſtry; where he ſhews the method of diſſolving common brimſtone in alcohol or highly rectified ſpirit of wine: To which *ſolution* the tincture here obtained bore a perfect reſemblance.

In thoſe deductions which that great chemiſt has drawn from this proceſs, he obſerves, that ſulphur (by which he means common brimſtone) muſt firſt be opened by an alcaly before it will diſſolve in the ſpirit.—That this ſubſtance frequently lies concealed in many foſſil bodies, from whence tinctures have been extracted, and impoſed on the world for the moſt valuable metallic ones. An inſtance of which he

he gives in one which was boaſted to have been made from gold, and concludes with an obſervation preventative of ſuch impoſitions. *As ſoon* (ſays he) *as a ſkilful artiſt diſcovers that a fixed alcaly is employed in making them, he knows they muſt proceed from ſulphur.** Conſequently, the tincture here obtained from the reſiduum of the Bath waters, muſt proceed from a ſulphureous principle of one kind or other which they contain. But that this is not *common brimſtone* is evident from hence, that when diſtilled vinegar was added to this tincture, no offenſive ſmell was produced; nor did any thing precipitate which was poſſeſſed of its properties. Whereas, if the ſame acid be mixed with the golden tincture of the before-mentioned proceſs in *Boerhaave*'s chemiſtry, there ſoon ariſes a *ſtercoraceous odour*, and *that mineral* ſubſides.

The ſulphureous principle, therefore, which is contained in the reſiduum of theſe waters, bears only this reſemblance to common brimſtone, that they both give a like colour to ſpirit of wine.

Now

* Simul ac enim cognoſcitur alcali requiri ad eaſdem conficiendas, peritus artifex ocyus cognoſcitur de ſulphure naſci.

Now if we conſider the compoſition of that *foſſil*, we ſhall find it is only one of its conſtituent ingredients* which is capable of producing this effect. Neither its alcaly, nor its acid ſpirit, are in any degree equal to it, and therefore it muſt be its bituminous part, or as *M. Homberg* expreſſes it, *le vrai ſouffre du ſouffre commun*. to which this alteration of colour is to be attributed.

Probably the ſulphureous principle of theſe waters may conſiſt of ſuch a bituminous matter. The preceding experiment favours ſuch a ſuppoſition; and the ſubſequent ones will, I preſume, confirm it.

1. If a large quantity of the Bath water, as 50 or 60 gallons, be evaporated with a very ſlow fire nearly to a dryneſs, or till only a quart or three pints of it be left; this remainder being poured off from the earthy parts, which the operation has collected, and paſſed through filtrating paper, appears in reſpect of its colour like mountain

* Brimſtone conſiſts of an alcaline part, an acid ſpirit, and a bituminous matter. *Vide* Eſſai de L'Analyſe de Souffre Com. *Memoirs de L'Acad. Royal, An.* 1703.

mountain wine, and in its ſmell, reſembles the balſam Tolu.

2. If an equal quantity of pure ſpirit of wine be poured to this *amber-coloured* water, the mixture immediately becomes turbid and milky, and continues ſo till the precipitation of a ſaline unchryſtalized maſs reſtores it to its original tranſparency and colour: The latter being now rendered fainter by the diviſion of the *ſulphureous matter*, which produced it, through the additional quantity of the ſpirit of wine.

3. When this ſaline maſs has entirely ſubſided, decant the clear liquor, and gently evaporate it. The vapour which at firſt ariſes is highly perfumed, but grows leſs ſo in proportion as the ſpirit of wine diminiſhes. When this is entirely exhaled, the watery part of the mixture recovers its former *balſamic* ſmell, and being at length totally driven away in ſteam, there remains a thick ſoapy liquor, of a hot, aromatic, pungent taſte, of a grateful

grateful fragrancy, and of a dark-brown colour.

This is the ſulphureous principle of the Bath waters. It is an exceeding fine aromatic balſam, entirely diſſimilar from common brimſtone, which has hitherto been ſaid to conſtitute this part of their compoſition.*

It

* What is here ſaid to be the ſulphureous principle of Bath waters, and which from its ſmell, taſte, and conſiſtence, is termed a balſam, has been declared to be nothing more than an oil. But that this matter is not an oil is evident from hence, that oil will not mix with water, and more eſpecially if the water, as this objector aſſerts it is, be impregnated with an acid. Had this writer made the ſame experiment, on which this opinion is grounded, with equal care and with all its circumſtances, he would ſcarcely have been ſo poſitive in his aſſertions. And to ſhew farther, how much ſulphur is concerned in the production of theſe waters, it will be Proper here to mention, that when the ſpring of the Hot Bath was laſt ſummer ſecured, a conſiderable quantity of this mineral was found adhering to the ſtones of the old foundation. Theſe ſtones lay between 10 and 11 feet below the ground plat of the bath; ſo that the ſulphur, which was lodged between their crevices, muſt have been brought thither by the water iſſuing from its ſource. Mr. Symons, by whoſe care the water of this bath has been reſtored to its original purity, which by the mixture of ſome cold ſprings had been much impaired, collected a conſiderable quantity of this matter, which, upon examination, gave every proof of its being common brimſtone.

It is impoſſible to determine the preciſe quantity of this principle in any aſſigned portion of the water, becauſe much of it flies off during the ſeveral evaporations which are neceſſary to collect it.

CHAP.

CHAP. IV.

Of the SALINE *and* EARTHY PRINCIPLES *of the* BATH WATERS.

WATER is ſo ready and ſo univerſal a ſolvent for all the various ſpecies of ſalts, that there is hardly ever found a ſpring ſo pure, but ſome one or other of this claſs of bodies make a part of its contents. Mineral waters eſpecially are never free from ſuch ingredients. Among them there are ſome which derive their whole virtue from hence; and indeed it would be hard to conceive how without ſuch aſſiſtance they could lay claim to that appellation, or be productive of any medicinal effects.

The kinds of ſalt which ſuch waters contain are diſcoverable by two methods of examination. The firſt conſiſts in the addition of peculiar ſubſtances to the water, from whence certain effects enſue that characterize the ſalts which produce them: And the ſecond, in evaporating it to a dryneſs, or till only an earthy matter remains, from whence the ſalts are afterwards to be ſeparated.

But

But introductory to these investigations, it may not be improper in this place to premise a short and general history of the different species of the properties of salts; which, though unnecessary to many readers, may yet be of such use to others, whose knowledge in chemistry is of small extent, that without it, the following account of the salts which are discovered in the Bath waters would be perfectly unintelligible.

"Salts, then, are defined to be fossil bodies,
"fusible by fire, and congealable again by
"cold into little glebes or chrystals; so-
"luble in water so as to disappear therein,
"and impressing a sensation of acrimony
"on the tongue.*"

This definition is general, and takes in the chief properties of all salts whatever; but as there subsist very essential and peculiar differences among them, they have been aptly divided into three distinct classes, which are distinguished by the terms, acid, alcaline, and neutral.

The

* Note on *Boerhaave*'s Chemistry, by *Shaw*, vol. 1. page 104.

The properties of acid ſalts are their particular taſte and ſmell; the fermentation they produce with alcaline and earthy ſubſtances; their diſſolving metals, and their ſtriking a red colour with the juices of the ſun-flower, roſes, and violets.

Alcalies are characterized by their maukiſh urinous taſte; by their effervеſcing with acids; by their precipitating metals and other ſubſtances diſſolved in them; by their readily uniting with oils and ſulphureous bodies; by their changing the juices of the ſun-flower, roſes, and violets green; and laſtly, by their diſſolving and running into a fluid ſtate when expoſed to the air.

The third claſs of ſalts, which are termed neutral, are conſtituted by the union of the preceding ones, and when perfect, neither ferment with acids or alcalies, nor indeed poſſeſs any of their properties. They are alſo ſufficiently diſtinguiſhed by their power of cryſtalizing, or ſhooting into regular diſtinct forms, which belongs not to either of the others.

As all ſalts whatever are comprehended under one or other of the preceding claſſes, and poſſeſs

poſſeſs the peculiar marks of their tribe, they are in a great meaſure to be diſcovered by the following experiments, as appears from their application in the preſent enquiry.

1. Having mixed ſome ſyrup of violets with the Bath water, it ſoon changed to a deep vivid green.

2. With a ſolution of quickſilver in aqua fortis it immediately became opake and yellow, and an orange coloured powder precipitated.

3. Acids cauſe no efferveſcence with the water, but their acrimony is greatly ſheathed and deſtroyed by it.

4. Neither with alcalies is any fermentation excited.

5. A ſolution of ſilver in aqua fortis turns the water milky, and the metal ſubſides.*

From the two firſt of theſe experiments we learn that the water contains an alcaly.—From the third, that this alcaly is either but in a ſmall quantity, or that it is not of a very active nature.—From the fourth, that no acid in a

 ſeparate

* The waters of each bath ſhew the ſame appearances.

ſeparate unmixed ſtate has any ſhare in its compoſition.—And from the laſt, that common marine ſalt makes a part of its contents.

As the phænomenon produced in the ſecond experiment admits only of the following ſolution, its explication therefore becomes an evidence for the veracity of that deduction which was drawn from it. For the menſtruum in which the quickſilver is diſſolved being a ſtrong acid, is on its mixture with the water changed to a neutral ſtate by the alcaline principle which exiſts there; and being thus ſo much altered from its original nature, it conſequently is now no longer capable of ſuſtaining that mineral.

To explain why milky clouds are generated in the water by dropping into it a ſolution of ſilver in aqua fortis, and why from thence, together with the precipitation of that metal, we conclude it contains common marine ſalt; it muſt be obſerved, that the two moſt perfect metals, ſilver and gold, diſſolve each in its own peculiar menſtruum, ſo as that the one is not in the leaſt affected by what proves a ſolvent for the other.—Thus ſilver diſſolves in aqua fortis, but gold does not.—Again, gold diſſolves in aqua regia, (a liquor made by the com-

combination of aqua fortis with marine ſalt) but ſilver is not in the leaſt acted upon by it. When therefore the ſolution of ſilver is mixed with the Bath water, the common marine ſalt which is contained in it, uniting itſelf with the aqua fortis, produces that peculiar menſtruum, (the aqua regia) which acts only upon gold: In which caſe, the ſilver muſt neceſſarily be diſcharged from a fluid now rendered incapable of diſſolving it; and thus for a time it ſwims about in the water, obſcures its tranſparency with milky clouds, and at length precipitates to the bottom of the glaſs in which the mixture was made.

It has been obſerved of neutral ſalts, that they alone have the power of congealing into glebes or chryſtals; the figures of which being extremely different, and each ſalt always retaining its own peculiar ſhape, this property becomes one of the moſt diſtinguiſhing ſigns of their ſeveral ſpecies.—Thus common marine ſalt produces chryſtals which are cubes: Thoſe of nitre are priſmatic: Thoſe of alum octogons; and ſo on of the reſt.

Now to obtain the ſalts of a mineral water in this perfection, that from their proper ſhape

it may be determined to what claſs they belong, it is neceſſary to evaporate large quantities of it, that all the fluid part being diſperſed in vapours, the earthy and ſaline ones may alone be left; from whence the latter are to be ſeparated by digeſtion in warm diſtilled rain water, which being filtred and gently evaporated till a fine ſkin covers its ſurface, muſt then be kept in a cool place, and thus the ſalts will in time be found chryſtalized in their diſtinct figures.

If the Bath water is treated according to theſe directions, it exhibits two ſpecies of ſalts, whoſe forms are elegantly expreſſed in the following plate, Fig. 1.

But I ſhall defer the particular deſcription of theſe for the preſent, to take notice of ſome phænomena which ariſe during the methods made uſe of to obtain them.

Whilſt the water evaporates, its ſurface is continually covered by broad thin flakes, which, as they gradually increaſe in their weight by the addition of ſimilar particles, at length become too heavy to be ſupported; and by ſubſiding, give room for others of the like nature

to

to ſucceed. The ſides alſo of the veſſel in which the evaporation is performed, are encruſted with a hard, ſaline, white matter, extremely pungent, and biting on the tongue.

When the water is entirely exhaled, the reſiduum conſiſts of the before-deſcribed flaky ſubſtances, and (if the heat uſed during the proceſs has been moderate) is of a *brown* colour, has a ſoft ſoapy feel, and a *balſamic* ſmell. On the contrary, if the heat has been violent, it is deprived of all theſe properties. The *balſamic* ſmell is not to be perceived; its floculi become brittle and harſh to the touch; and change their natural brown for a ſnowy whiteneſs. Which alterations are other inconteſtible proofs of a bituminous principle that originally exiſted in this reſiduum; by whoſe eſcape the above changes neceſſarily enſue.

This reſiduum has no diſtinguiſhable ſaline taſte, but is rough and gritty in the mouth.—It ferments violently with ſpirit of vitriol, and other acids; as do alſo thoſe ſaline concretions which adhere to the ſides of the evaporating glaſſes. They raiſe no diſturbance whatever with alcalies, and being digeſted in pure diſ-

tilled rain water, they communicate to it the property of turning *green* with ſyrup of violets.

Such appearances confirm thoſe concluſions, which were drawn from the changes the Bath water underwent by the mixture of particular ſubſtances with it; and are further demonſtrations of its containing an alcaline principle. But whether this is a ſalt, or only an earthy matter inclining to that nature, we muſt be determined by the following experiment.

Let a large quantity of the water be evaporated till only a ſmall portion of it remains; this will be extremely ſalt, and if poured off from the earthy parts, and exhaled to a dryneſs, we ſhall thus collect this principle by itſelf, and pretty free from every other addition.

The ſaline maſs here obtained neither ferments with acids, nor produces any change of colour with ſyrup of violets: Nor does the white concretion, which ſticks to the ſides of the evaporating glaſſes, yield any other than a perfect neutral ſalt, when diſſolved and chryſtalized; and its filter'd ſolution ſhews no ſigns of alcaleſcency.

Hence

Hence this alcaline principle does not conſiſt in a *ſalt*, but in an *earthy matter*; of which we ſhall hereafter ſpeak more particularly.

It has been obſerved, that there are two ſpecies of ſalts in the Bath waters: The firſt of which reſembles in its figure Dr. *Liſter*'s calcarious nitre, and is undoubtedly the ſame ſalt. * Its chryſtals are long and ſlender; they conſiſt of four unequal ſides, the upper and inferior being broader than the lateral ones. At one end, the chryſtal terminates in two triangular ſurfaces; at the other, in two inclined planes. Fig. 2.

This ſalt is at firſt remarkably cool in the mouth, but impreſſes a ſtrong bitter taſte as it diſſolves. It is free from any acrimonious biting ſenſation; nor has it that nauſeous ſavour which the common purging ſalts leave behind them. Being flung into milk which is near

 boiling,

* Salis calcarii chryſtalli tenues, longæque ſunt: iiſque mediis quatuor latera parallelogramma ſunt at ferâ inæqualia; ex alterè vero parte, ipſe mucro ex binis planis lateribus triangularibus formatur, ex altera & adverſa parte duo plana quadratur habet, perpetuò ad contrarium cum priore illa parte poſitum.——*Tractatus de Fontibus Medicatis Angliæ.*

boiling, it curdles it, and produces a *whey*. It ferments gently with ſpirit of vitriol, and yields a gaſs, which ſmells like aqua fortis. It does not ferment with alcalies, but turns ſyrup of violets of a faint green. Being flung on a red-hot iron, it immediately melts, and runs into a fluid ſtate like water, hiſſes, forms bubbles, and at length changes into a white calx. On live coals it produces the ſame appearances. If it is put before a fire, or kept in a hot place, it loſes both its tranſparency and hardneſs; becomes white, and falls into a powder on the ſlighteſt touch.—We confined a few ounces of this ſalt in a glaſs retort, and gave it a ſtrong fire for ſeveral hours. There at firſt came over into the receiver a conſiderable quantity of a taſteleſs, inſipid water, which gave no ſigns, either with acids or alcalies, or ſyrup of violets, of its being any other than a pure elementary fluid. This was followed by a ſmall portion of an acid ſpirit. The maſs which remained in the retort was an alcaline earth.

A ſolution of this ſalt precipitates ſilver diſſolved in aqua fortis; which property is, I believe, not eſſential to it, but is owing to ſmall portions

portions of marine ſalt, which in the microſcope are ſeen adhering to its cryſtals.

'Tis this marine ſalt which makes the ſecond ſpecies in the compoſition of theſe waters, as is evident from its poſſeſſing the following ſigns: 1ſt. The cubical figure of its chryſtals.—2d. Its peculiar ſalt taſte.—3d. If the oil of vitriol is dropt on it, there ariſes an acid ſuffocating gaſs, or the true ſpirit of ſea ſalt.

In 56 cubic inches,* or one quart wine meaſure of the King's-Bath water, there is found, both by its evaporation and diſtillation, 34 grains of reſiduum. The proportion of the water therefore to its fixt contents, is as 417 to 1.

Twenty grains of this reſiduum diſſolve in rain water, the other 14 ſubſide. Hence the former are ſalt, the latter earth.

Theſe two ſpecies of ſalt exiſt in the King's-Bath water, under different proportions. The neutral being to the marine ſalt, as 2 to 5; con-

* The wine gallon is ſuppoſed to contain 231 cubic inches, but from an experiment made in 1688 before the Commiſſioners of the exciſe, &c. it was found that the preciſe content of the ſtandard wine gallon kept in *Guildhall* was but 224 cubic inches.

conſequently in a wine quart we have 5,714 grains of the neutral ſalt, and 14,285 grains of the marine ſalt.

One quart of the Hot-bath water gave 30 grains of reſiduum; 17 of which were earth, and 13 ſalt.

The ſame quantity of the Croſs-Bath alſo left 30 grains of reſiduum, 10 of which were ſalt, and the remainder earth.

The proportion therefore of the fluid parts to the ſolid, in both theſe waters, is as 472, 6 to 1.

The water of the Hot-Bath contains a larger ſhare of the neutral ſalt than the Croſs-Bath.

After theſe ſalts are entirely ſeparated from the reſiduum, there remains an earthy powder of a white colour, and a perfectly inſipid taſte.

Its peculiar nature will be diſcovered by the following experiments:

1ſt. It does not ferment with oil of tartar, or with any of the alcaline claſs.

2d. It gives a faint green to ſyrup of violets.

3d. It

3d. It ferments violently with ſpirit of vitriol, and all other foſſil acids.

4th. After being calcin'd, it fermented more ſtrongly with acids than before, but did not increaſe the heat of common ſpring water, nor did any hiſſing or ebullition ſucceed on their mixture.

5th. I added to this earthy matter a little borax and tallow, and then placed it in the heat of a wind furnace for ſome hours. When the maſs had grown cold, and was pounded, the loadſtone drew ſeveral ſmall particles of iron from it.

From theſe experiments we may with certainty conclude, that the earthy part of the Bath water is of an alcaline nature; but it does not ſeem to be derived from limeſtone, as in that caſe it would have ſhewn its peculiar properties after *calcination*, and conſequently have produced an ebullition with ſpring water, and increaſed its heat.

It alſo appears that the calx of the *chalybeat* principle of theſe waters remains in their reſiduum, and may be reſtored by proper methods

to

to its genuine metalleity; which is ſurely a convincing proof, that the general opinion of its being *volatile* is erroneous.

The earthy ingredient of theſe waters is alſo to be obtained, by only mixing the ſalt of tartar or its lixivium with them; for immediately on this addition, large white clouds appear, and at length precipitate in a fine powder; which (after being well waſhed in ſeveral waters, to ſeparate any part of the alcaly which might have adhered to it) fermented violently with all the mineral acids in general.

This powder ſhews no ſigns of inflammability whatever; it is merely an abſorbent, alcaline, calcarious earth.

The laſt principle which we find in the Bath waters is air.* It has been obſerved by Dr. *Hales* that they contain leſs of this element than other mineral

* The properties of fixt air were not diſcovered when this Tract was firſt publiſhed. Much of the virtue of mineral waters, may, I apprehend, be juſtly aſcribed to it. But the Thermæ, or Hot Mineral Waters, contain a ſtill more powerful principle, namely Fire; with whoſe nature and properties philoſophy is not yet acquainted; and till it becomes acquainted with them, our reaſonings on the cauſes of their medicinal virtues muſt neceſſarily be defective.

mineral or even common waters do; and by following his method of ſeparating the air from fluids*, I obtained from a Florence flaſk of the King's-Bath water, by 160 degrees of heat, a bubble, whoſe diameter was only $\frac{5}{8}$ of an inch; from the Hot-Bath water one of $\frac{3}{8}$; and from the Croſs-Bath about the ſame quantity: whereas a Florence flaſk of common pump water yields a cubic inch of elaſtic air.—Thoſe of *Briſtol* and *Holt* a like portion; and *Piermont* water near twice as much.‡

* See *Veg. Statics*, vol. 2, page 270.

‡ See *Veg. Statics*, vol. 1, page 181.

CHAP. V.

How the BATH WATERS *are generated.*

WE learn from the preceding analyſis, that elementary fire, air, an alcaline earth, a neutral ſalt, common marine ſalt, iron, and a fine aromatic balſam, mixed together and diſſolved in pure water, conſtitute theſe fountains of health.

How ſpring water becomes poſſeſſed of thoſe rich ingredients, or in other words, how the Bath

Bath waters are generated, I ſhall now attempt to explain; and if I am able to make an artificial water, which ſhall reſemble the natural one in its moſt eſſential characteriſtics, it is all that can be expected in ſo difficult an undertaking.

It has already been obſerved that theſe waters bring up with them a very peculiar ſort of ſand, which is compoſed of an alcaline earth, iron, and brimſtone.—Upon the ſuppoſition then that common ſpring water, by running through beds of the ſame materials, becomes impregnated with the ſame principles which we find in the Bath waters; let us try how far the imitation of them will ſucceed, by making this the foundation of our enquiry.

I mixed with equal quantities of filings of iron and of ſtone brimſtone,* both reduced to

* It is moſt probable that Bath water is produced by common ſpring water running through beds of pyrites; a mineral chiefly compoſed of iron and brimſtone. "Circa thermas æſtuantes ita ſtatuendum eſſe arbitror, viz. particulas aerias unâ cum aquis pluvialibus in altam tellurem deſcendentes, ibidemque mineræ ſalino-ſulphuriæ occurrentes, æſtum, caloremque admodum intenſum in eadem excitare; & demum aquarum ſcaturagines e minera eo modo exæſtuante profluentes, thermas conſtituere.

Moyow. page 261.

to a powder, about four times their weight of free-ſtone ſand. This compoſition was moiſtened into a paſte with common water. In about ſixteen hours it became ſo violently hot as to break in pieces a ſtrong earthen pan in which it was kept; and it had lain ſcattered, and ſmoaking on the ground, for ſome time before the accident was diſcovered.

This accident rendered a repetition of the experiment neceſſary; which being made in a metalline veſſel, the ſucceſs was equal to expectation; for the water poured on this mixture grew hotter than that of the bath, and having inadvertently ſuffered a Farenheit's thermometer to ſink too deep among the ingredients, the mercury was flung up to the utmoſt extent of the tube, whoſe ſcale meaſured 393 degrees, and the bulb of it burſt.

This water, in which the above compoſition was digeſted, threw up a little ſcum on its ſurface, and depoſited an ocre on the ſides of

of the veſſel which contained it.* It was tranſparent and vivid. It had an agreeable chalybeat taſte. It inſtantly turned purple with tincture of galls—green with ſyrup of violets—of an orange colour with a ſolution of quickſilver in aqua fortis—milky with oil of tartar per deliquium—it precipitated a ſolution of ſilver, and ſhewed no change or alteration whatever with acids. In all which particulars it perfectly agrees with the Bath water. Some difference was however obſerved between them, which aroſe from the different proportions of their ſeveral ingredients; and not from the defect of any particular one, in the compoſition of the artificial water; which contained more of the chalybeat, and leſs of the alcaline principle, than exiſts in the other.

The artificial Bath water left by evaporation a reſiduum of a browniſh colour, which gave no flame on a red-hot iron, but communicated

* The Guides clear the ſurface of the baths of this kind of ſcum every morning before the bathers come in.—An ocre may be ſcraped off the ſides and ſtone ſeats of the baths, which are in moſt place tinged by it of a yellowiſh colour.

municated a fine amber tincture to ſpirit of wine: And part of it being digeſted with diſtill'd rain water, and the ſolution cryſtaliz'd, the ſame ſpecies of ſalts were obtained, as thoſe which the natural water yields by the like treatment.

From this analogy between the artificial and the natural waters, it is evident the latter are generated in the manner I have ſuppoſed. Thoſe ſmall differences which have been noticed between them will ſcarcely be called objections to this theory: For it would be abſurd to imagine that chemiſtry can afford us the power of making ſo perfect a compoſition, as that which nature produces. It is the province of this art to imitate her operations, and from that imitation to explain them. For, as Mr. *Lemery* obſerves, * " Le meilleur moyen d'expliquer la " Nature, (s'il pouvit être employé ſouvent) " ce ſeroit de la contrefaire, & d'en donner pour " ainſi dire, des repréſentations en faiſant pro- " duire les mêmes effects a des cauſes que l'on " connoîtroit, & que l'on auroit miſes en ac- " tion. Alors on de devineroit plus, on veroit " de ſes yeux, & l'on feroit ſûr que les Pheno-

 " menes

* Hiſt. de l'Acad. Roy. An. 1700.

" menes naturels auroient les memes cauſes " que les artificiels, ou du moins, des cauſes " bien approchantes."

It now only remains, that we ſhew, how from the action of theſe bodies on each other, the ſeveral principles of the Bath Waters are produced. To this end, it muſt be premiſed, that iron powerfully attracts acids; and that brimſtone is compoſed of an acid ſpirit, a bitumen, and an alcaline part.—When theſe two bodies then come into cloſe contact, a ſolution of the iron, by the acid ſpirit of the brimſtone, immediately commences. By this means, that metal is converted into a ſalt or vitriol; which ſalt or vitriol makes the *chalybeat* principle of the Bath waters.

When the acid ſpirit is thus ſeparated from the brimſtone, its bituminous and alcaline parts only remain: The former of which being rendered ſoluble in water by the aſſiſtance of the latter, conſtitutes the *ſulphureous* principle of the Bath waters.*—Hence we ſee it is impoſſible

* Cette Balſam tire du ſouffre commun a une odeur grate & balſameque.—Analyſe du Souffre par M. *Homberg*.——*Memoirs de l'Acad. Royal, An.* 1703.

ſible that theſe ſprings ſhould contain common *brimſtone*, as in their production the texture of that mineral is entirely deſtroyed, and it is robbed of *one* of its *conſtituents*.

The *alcaline* principle of the Bath waters is ſupplied either from freeſtone ſand, or ſome chalky earth: Probably from the latter, as the artificial water was found to contain leſs of this ingredient than the natural one.

Marine Salt, or Sal Gemmæ, (for they are both the ſame) is ſo univerſally diſtributed through the bowels of the earth, that there are no ſpring waters but what are impregnated with ſome portion of it.

The calcarious nitre, or neutral ſalt of theſe ſprings, is compoſed of a vitriolic acid, and an alcaline earth; and does not, I believe, primarily exiſt in them, any more than it does in the artificial water, which has been made in their imitation; but is generated while the waters evaporate. For heat applied to the Bath waters, as well as to all other chalybeats, deprives them of their properties of tinging with galls; that is, it ſeparates the acid from

the iron by which it was rendered miſcible with the water, and the metal ſubſides: While the acid ſpirit, in which it was before diſſolved, is abſorbed by the alcaline earth, and this neutral ſalt is formed.—Hence we ſee the reaſon why no *vitriol* or *ſalt* of *iron* is ever to be found in the *reſiduum* of chalybeat waters; why this principle exiſts there in the ſtate of a *calx*; and why from all waters of this claſs we obtain a *neutral* ſalt of the ſame kind.* *Hoffman*, ſpeaking of this ſalt, obſerves, "‡ That it cannot "be diſcovered by the addition of any parti- "cular ſubſtances to the water, but readily by "exhaling it to a dryneſs:"—For which, if the above ſuppoſition is admitted, we can be at no loſs to account.

The laſt thing to be explained, is the remarkable heat with which theſe waters are endued;

* In Pyrmontanis, in librâ unâ Salis medii grana vii ad x continentur; in Egranis et Salterenſibus grana plura; in Sualbecenſibus & Spadanis, pauciora.—*Heiſter de Aquar. Medicatarum naturâ et uſu.*

‡ Quod reagentium ope difficulter admodum, vel plane non erui & detegi poſſit, ſed ſola Liquoris *exhalatione* & *reſiccatione* ſeſe conſpiciendum præbeat.——*Hoffman de Elementis Aquarum Mineralium, &c. Sect.* 50.

duced; and here, if I have recourſe to the antient opinion, that fire is an element *ſui generis*, and that it makes a part in the compoſition of all bodies whatever; I ſhall not be unſupported by many great names among the moderns, ſuch as *Homberg*, *Lemery*, *Graveſande*, and *Boerhaave*. It may be alſo be added, that the late diſcoveries in electricity tend very much to confirm and eſtabliſh this doctrine. I chuſe therefore to aſcribe that great degree of heat which is found in the Bath waters to elementary fire, as to its moſt probable cauſe. *This*, if it exiſts in any bodies at all, does ſo moſt eminently in iron and brimſtone. It ſhould ſeem then, that theſe waters, by waſhing off, ſeparating, and taking up, in their paſſage through the earth, the particles of theſe minerals, ſet at liberty this impriſoned *element*, which thereupon communicates its warmth and activity to the fluid.

I know not, whether I have given the reader all the ſatisfaction he expected in the peruſal of the foregoing ſheets. If I have not, I can only apologize for my deficiencies in the words

words of the great Mr. *Boyle*, who obſerves, that "To diſcover the nature of mineral wa-"ters is a far more difficult taſk than thoſe who "have not tried would imagine."

An

An Explanation of the Copper-Plate.

Fig. I.

SHEWS the Salts of the Bath Water, as they chryſtalized at the bottom of a glaſs pan.

The *Squares* are Marine Salt.

The *long Chryſtals* are calcarious nitre.

The *irregular Figures* are made up of both, and are occaſioned by theſe ſalts ſhooting too near together, and thence preventing each other's Chryſtals from forming in their own, determinate ſhape.

Fig. II.

Exhibits a Chryſtal of the calcarious nitre drawn from the microſcope; with ſeveral portions of marine ſalt adhering to it.